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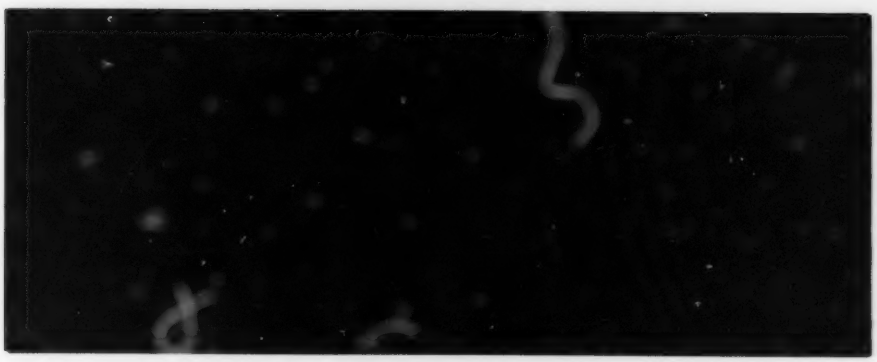

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Final Report - R-86-05-0184

Evaluation of Reasons for Vigor and Performance Differences Between Pedigreed Seed Lots of Spring Barley (*Hordeum Vulgare* L.) and Spring Wheat (*Triticum Aestivum* L.) and Seed Lot Vigor Testing Procedures

Conducted by Dr. B. Rossnagel and Dr. R. Baker

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Final Report of Project

EVALUATION OF REASONS FOR VIGOR AND PERFORMANCE DIFFERENCES BETWEEN PEDIGREED SEED LOTS OF SPRING BARLEY (HORDEUM VULGARE L.) AND SPRING WHEAT (TRITICUM AESTIVUM L.) AND SEED LOT VIGOR TESTING PROCEDURES.

April 1987 - June 1989

to the Canadian Seed Growers Association

and the Saskatchewan Seed Growers Association

Dr. B.G. Rossnagel and Dr. R.J. Baker

Senior Research Scientists

Crop Development Centre

University of Saskatchewan

Saskatoon, Canada

OBJECTIVES:

The original objectives of this research project were:

(a) To identify non-genetic factors affecting seedling vigor and final crop performance differences between seed lots of barley and wheat.

(b) To determine why these differences occur and make recommendations to seed producers as to how to produce seed of maximum quality.

(c) To evaluate seed lot vigor testing procedures.

A resulting sub-objective was:

(a) The demonstration of differential seed lot performance even in the absence of kernel size differences.

METHODOLOGY:

Forty 25 kg samples of Pedigreed Harrington two-row malting barley and fifty 25-kg samples of Pedigreed Katepwa hard red spring wheat, produced during the 1986 growing season, were collected from seed growers across the Prairies (Figures 1 and 2 respectively) early in 1987. In addition to supplying the seed lot stocks each producer was asked to reply to a lengthy questionnaire regarding the production, handling, processing and storage of the seed lot.

Upon receipt of the seed lots, kernel size differentials were eliminated by screening each lot using a Carter Dockage Tester with a 6/64" x 3/4" slotted sieve. A portion of this uniformly screened seed was used to plant the 1987 field trials. The remainder was used for various seed analyses or stored under cool dry conditions and then used to plant the 1988 field trials. Varietal purity was verified for each lot by protein electrophoresis.

Each lot was tested for several physical, chemical and quality characteristics as listed below:

(a) Vigor tests

- standard % germination at 20°C
- cold % germination at 5 C
- germination rate
- time to 50% germination
- germination value
- mean length incubation time
- radiation stress testing
- radiation germination
- radiation sensitivity
- LD 25 and LD 50 (wheat only)
- vigor index

(b) Physical, organic and quality characteristics

- test weight
- weight per 1000 kernels
- kernel density
- kernel hardness (wheat only)
- protein concentration
- oil (fat) content
- viscosity (barley only)
- alpha-amylase activity (barley only)
- diastatic power (barley only)
- seed leachate conductivity

(c) Mineral contents

- Phosphorous
- Potassium
- Sulfur
- Calcium
- Magnesium
- Copper
- Iron
- Manganese
- Zinc
- Boron

Field evaluations were conducted during 1987 and 1988 using multi-replicate standard small plot field trials. Trials were grown at Saskatoon (8-replicate randomized complete block designs (RCBD) in 1987 and 16-replicate RCBD's in 1988), at Watrous (wheat only, 4 replicate RCBD - 1987 and 1988) and at Indian Head (barley only, 4 replicate RCBD-1987 and 1988). Emergence was determined at all sites except for Indian Head and Watrous in 1987. Seedling development was measured using the Haun scale at all sites in 1988 only. Each plot was harvested for grain yield at all locations except that the barley trial at Saskatoon in 1988 was abandoned due to drought.

Analysis of variance was used to evaluate emergence, seedling development and yield differences among seed lots. Correlations were calculated among the various seed factors, vigor ratings and field performance characteristics. Using these analyses, multiple linear regressions were calculated with final yield and emergence as dependent variables. Seed characters demonstrating significant correlations with emergence and yield were the independent variables.

RESULTS:

Combined analysis of variance indicated that the wheat and barley seed lots, despite being genetically the same and having had seed size differential eliminated (there was no significant association between field performance and kernel weight in either the wheat or barley lots as shown in Tables 5 and 6), both demonstrated significant variability in field performance in terms of emergence (Tables 1 and 2) and grain yield (Tables 3 and 4). The maximum yield differential among barley lots was 14.3% and for wheat it was 13.6%. No significant differences were detected among seed lots in regard to seedling

development as measured by Haun stage.

Correlation studies indicated a significant association between emergence and yield for both crop kinds, but none between seedling development and yield (Tables 5 and 6). Since final yield differences resulting from differential emergence may often be masked by environmental influences during the remainder of the growing season, it was decided to consider vigor rating and seed lot characteristic relationships with both emergence and final yield in this research project.

For the wheat seed lots simple correlation coefficients are shown in Table 5. Emergence and yield were both positively correlated with standard and cold germination percentage and vigor index while yield was also positively related to radiation germination and the radiation stress test LD 25. None of th

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appears to be a useful tool in that case. Mmultiple linear regression analysis indicated that the greatest proportion of the variability in wheat yield could be accounted for by a model combining information from both % cold germination and the radiation stress test LD 25 values. This combination was considerably superior to standard germination % alone.

As noted in Table 6 several traits were significantly related to both emergence and yield in the case of the barley seed lots. In fact, both emergence and yield were significantly related to all nine vigor tests. With the exception of the relationships with MLIT and time to 50% germinat'on all correlations were positive. Both parameters were positively related to the seed lot traits test weight, density, viscosity and diastatic power while emergence was also positively correlated with alpha-amylase activity and oil concentration. The lack of correlation with protein content is again notable. Unlike the situation for the wheat seed lots, a number of mineral concentrations showed significant correlation with emergence and yield in barley. Of particular note were the negative associations between copper and iron content and both performance parameters. Calcium content was also negatively correlated with emergence while potassium content demonstrated a positive relationship.

Regression analysis in regard to barley seed lot emergence and seed lot parameters resulted in three multi-component models which each accounted for over 60% of the variability for emergence. These models involved: (1) density, diastatic power and alpha-amylase activity, (2) density, oil concentration and diastatic power, or (3) density, viscosity and alpha-amylase activity. Of these models the first, involving density and the two measures of enzyme activity is most logical.

When vigor tests were considered variability in barley emergence was best accounted for by cold germination percentage. However, as was the case for the wheat lots, standard germination percentage alone accounted for nearly as great a proportion of the variability as well, 67% versus 73%.

In regard to barley yield, seed density accounted for the greatest

portion of variability, 33%. Cold germination percentage accounted for 42% while standard germination accounted for 32% of the variability.

Seed grower survey results were rather unsatisfactory with only 38/50 wheat and 27/40 barley seed lot suppliers returning questionnaires, despite receiving them three times. In addition, there was considerable variation in regard to the questions answered and the detail which was or was not supplied. Particularly disappointing was the fact that for each crop kind no survey was received from the grower of the poorest performing lot. The only tangible survey result was that in the case of the barley all the poorest performers in terms of yield and emergence had suffered weathering damage during the harvest period, especially prolonged exposure to high moisture conditions after swathing and prior to combining. While not as evident a similar pattern appeared in regard to the wheat lots.

CONCLUSIONS:

(1) Even in the absence of differential kernel size, genetically identical seed lots of hard red spring wheat and barley can give rise to differential field performance in terms of emergence (stand) and eventual grain yield.

(2) Of several vigor tests evaluated, % germination at low temperatures (cold germination) appears to be the single best test of seed lot vigor. However, standard % germination at 20°C is also a reasonably reliable indicator. Samples with low standard germination are likely generally less vigorous, however high standard germination does not guarantee high vigor.

(3) The novel Radiation Stress Technique, while of some apparent value in segregating vigor levels, is apparently no better than % germination and therefore offers only an alternative evaluation, not a superior one.

(4) Protein content of the seed does not appear to be a major factor affecting emergence or yield of either wheat or barley.

(5) With the exception of copper and iron content in the barley lots, seed mineral content was not consistently related to field performance. Given the high cost of determination of mineral content and the fact that both significant relationships were negative (meaning the concentration of the minerals would have to be lowered rather than raised), it appears that little could be done in terms of macro or micro nutrient application to improve seed quality.

(6) Weathering of the grain after swathing and prior to harvesting are obviously very detrimental to seed lot vigor. This was particularly evident in the case of the barley lots evaluated. Everything feasible should be done to avoid this situation in barley and when it does occur growers and purchasers should be advised to pursue additional vigor tests beyond conventional % germination. This should be done to ensure that their product is of good quality even if it has a sound appearance. It appears the two best and simplest additional tests to pursue would be % germination at cold temperature (4°C) and an accurate measurement of seed density.

(7) Accurately measured barley seed density may provide an inexpensive and relatively accurate method to quantify weathering damage. This procedure may also be of value to malting barley selection processes which consider similar parameters as do those of seed lot vigor.

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Figure I. Locations from which Harrington barley seed lots were obtained.

Figure 2. Locations from which Katepwa wheat seed lots were obtained.

Table 1. Average emergence of Katepwa wheat seed lots, 1987-88.

Seed lot #	Plants/m^2	Seed lot #	Plants/m^2
50	107.9	34	98.2
8	107.1	14	97.7
45	106.1	39	97.6
1	105.0	29	96.7
12	103.1	40	96.7
5	102.9	23	96.6
4	102.8	26	96.1
13	102.7	21	95.6
10	102.6	9	95.5
19	102.0	30	94.6
44	101.2	32	94.4
49	101.1	7	93.8
41	101.0	22	93.8
11	100.7	16	93.2
38	100.7	37	93.0
25	99.9	46	92.8
35	99.2	43	92.4
31	99.1	28	92.0
36	98.8	15	91.1
24	98.8	42	90.1
6	98.8	27	89.8
20	98.7	17	89.6
3	98.7	47	89.5
33	98.6	18	85.1
2	98.6	48	80.8

Minimum significant difference (P=0.10) = 18.5

Table 2. Average emergence of Harrington barley seed lots, 1987-88.

Seed lot #	plants/m^2	Seed lot #	plants/m^2
12	185.2	39	159.3
15	178.5	35	156.6
22	177.6	2	156.1
20	177.5	13	155.8
4	177.3	19	155.7
17	172.3	23	153.9
7	172.2	28	153.9
21	169.4	29	153.3
38	167.7	11	153.1
37	167.2	16	152.8
3	167.2	25	151.3
34	166.9	1	151.2
5	165.9	27	150.9
8	165.5	9	150.8
10	164.9	33	149.2
14	163.9	32	142.8
24	163.3	36	132.3
40	162.4	30	124.7
31	161.2	6	116.7
26	161.2	18	94.2

Minimum significant difference (P=0.10) = 37.4

Table 3. Average grain yield of Katepwa wheat seed lots, 1987-88.

Seed lot #	kg/ha	Seed lot #	kg/ha
4	1599	14	1492
5	1592	46	1488
22	1586	45	1486
1	1564	12	1476
20	1557	10	1476
32	1551	40	1474
24	1548	38	1472
2	1538	25	1471
6	1536	34	1469
23	1534	27	1461
42	1526	18	1460
33	1519	16	1460
44	1518	28	1459
26	1514	47	1458
9	1512	37	1453
11	1512	21	1453
49	1506	43	1453
7	1504	36	1452
50	1504	3	1447
30	1501	35	1443
29	1501	13	1438
41	1501	8	1436
15	1498	17	1429
31	1495	39	1412
19	1493	48	1407

Least significant difference (P=0.05) = 97.8 kg/ha

Table 4. Average grain yield of Harrington barley seed lots, 1987-88

Seed lot #	kg/ha	Seed lot #	kg/ha
3	4634	19	4434
9	4569	11	4428
29	4552	32	4425
4	4550	20	4418
39	4543	31	4414
1	4528	13	4413
8	4519	37	4403
5	4511	15	4395
35	4495	34	4390
33	4492	23	4387
21	4483	2	4364
12	4471	38	4363
24	4463	14	4352
25	4460	30	4338
10	4460	16	4336
26	4454	36	4299
22	4450	40	4285
7	4450	6	4218
28	4444	27	4217
17	4442	18	4053

Minimum significant difference (P=0.10) = 474.3

Table 5. Correlation coefficients between variables measured for Katepwa wheat seed lots and combined field performance.

Variable	Emergence	Yield
Vigor tests		
Vigor index	0.45**	0.32*
Cold germination	0.54**	0.29*
Germination value	0.25	0.10
MLIT	0.11	-0.02
Time to 50% germ.	0.11	0.01
Radgerm	0.16	0.30*
Radsens	-0.06	0.17
LD50	0.25	0.26
LD25	-0.08	0.40**
Germ. rate	-0.07	0.04
Germ. percentage	0.48**	0.29*
Seed characteristics		
Conductivity	-0.01	-0.06
Hardness	-0.06	-0.17
Kernel weight	0.04	0.18
Test weight	0.17	0.15
Density	0.22	0.18
Protein %	0.01	0.01
Oil %	0.10	0.04
Emergence and Haun Rating		
Emergence	n/a	0.29*
Haun stage	n/a	0.01
Mineral content		
Phosphorous	0.02	0.23
Potassium	0.04	0.03
Sulfur	0.46**	0.23
Calcium	0.04	-0.19
Magnesium	0.00	0.29*
Copper	0.26	0.26
Iron	0.11	0.14
Manganese	0.12	0.09
Zinc	-0.17	-0.33*
Boron	0.12	0.09

*,** - significant correlations at P=0.05 and P=0.01, respectively
n/a - not applicable

Table 6. Correlation coefficients between variables measured for Harrington barley seed lots and combined field performance.

Variable	Emergence	Yield
Vigor tests		
Vigor index	0.80**	0.56**
Cold germination	0.86**	0.65**
Germination value	0.59**	0.32*
MLIT	-0.60**	-0.47**
Time to 50% germ.	-0.66**	-0.51**
Radgerm	0.74**	0.53**
Radsens	0.71**	0.51**
Germ. rate	0.72**	0.51**
Germ. percentage	0.82**	0.57**
Seed characteristics		
Conductivity	0.23	0.08
Kernel weight	0.19	0.17
Test weight	0.51**	0.50**
Density	0.68**	0.57**
Viscosity	0.59**	0.34*
Protein %	0.21	0.09
Oil %	0.40**	0.08
Diastatic power	0.66**	0.35*
Alpha-amylase activity	0.53**	0.24
Emergence and Haun Rating		
Emergence	n/a	0.60**
Haun stage	n/a	0.13
Mineral Content		
Phosphorous	0.08	0.03
Potassium	0.32*	0.18
Sulfur	0.20	0.02
Calcium	-0.33*	-0.16
Magnesium	0.12	0.03
Copper	-0.41**	-0.35*
Iron	-0.56**	-0.39**
Manganese	0.10	0.06
Zinc	-0.19	-0.11
Boron	0.18	0.12

*,** - significant correlations at P=0.05 and P=0.01, respectively
n/a - not applicable